OPTO-ELECTRIC WIRING BOARD

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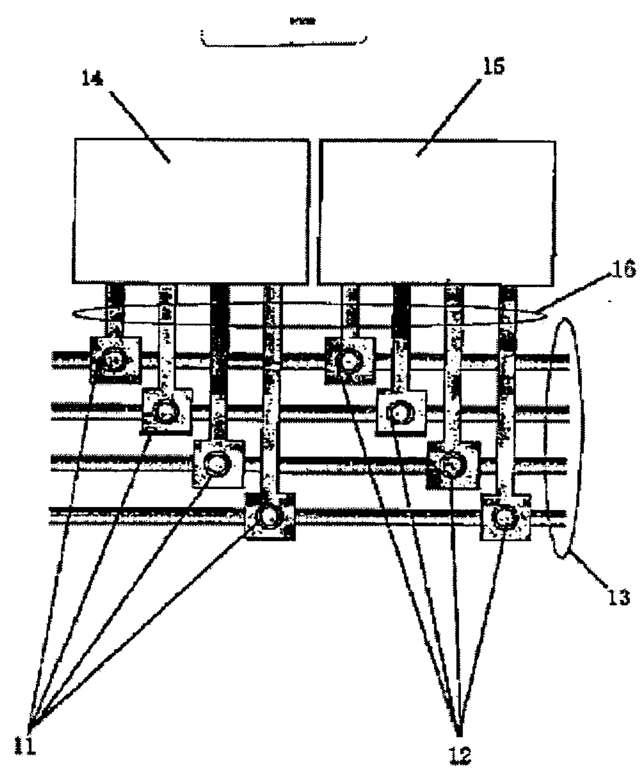
Abstract of **JP2001042145**

PROBLEM TO BE SOLVED: To make it possible to easily couple optical waveguides and electric-optical conversion elements having multiplayered reflection films by arranging the elements on the optical waveguides and integrating optical path converters or couplers for bending the direction of light in the optical waveguides right under the electric-optical conversion elements, thereby forming an electro-optic wiring board formed with the optical waveguides in an electro-optic wiring board formed with the optical waveguides. SOLUTION: Surface light emitting lasers 11 which are the electric-optical conversion elements and photodetectors 12 are packaged on the optical waveguides 13 on the electro-optic wiring board. A drive circuit 14 for the surface light emitting lasers 11 and an amplifier circuit 15 of the photodetectors 12 are integrated in proximity to the optical waveguides 13 in the form of chips to the electro-optic wiring board. The electric-optical conversion elements 11 and 12 and the circuits 14 and 15 are connected by wiring 16 between the elements and the circuits. As a result, there is no labor for making the exit light of laser beam sources on the optical waveguides from their end faces and the efficient coupling of the exit light to the optical wavegudies is made possible by the flip-chip packaging of the laser beam sources onto the electro-optic wiring board.



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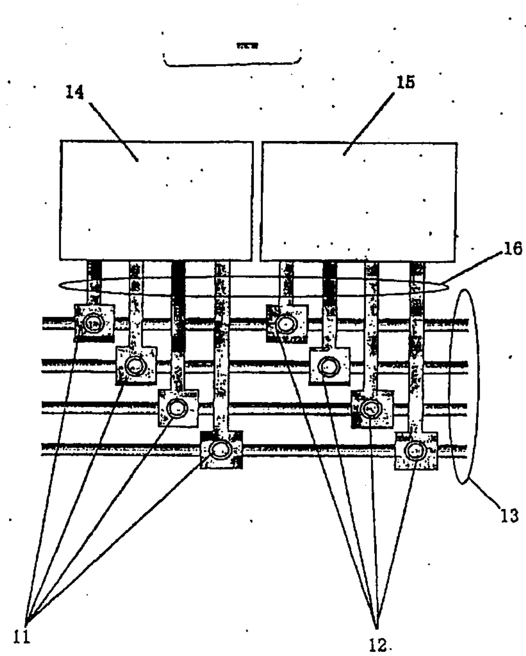
(54)【発明の名称】　光電気配線基板

(57)【要約】
【課題】電気－光変換素子を効率的かつ簡易に光導波路と結合させられる光電気配線基板である。
【解決手段】光電気配線基板上に光導波路１３が形成されている。多層反射膜を有した電気－光変換素子１１、１２が光導波路１３上に配置され、かつ、光の方向を折り曲げる光路変換器が電気－光変換素子１１、１２直下の光導波路１３中に集積化されて形成されている。



【特許請求の範囲】

【請求項１】光導波路が形成された光電気配線基板であって、多層反射膜を有した電気－光変換素子が該光導波路上に配置され、かつ、光の方向を折り曲げる光路変換器が該電気－光変換素子直下の光導波路中に集積化されて形成されていることを特徴とする光電気配線基板。

【請求項２】前記電気－光変換素子のうち、発光素子は活性層が多層反射膜で挟まれた構造の垂直共振器形面発光レーザ（ＶＣＳＥＬ）であることを特徴とする請求項１記載の光電気配線基板。

【請求項３】前記電気－光変換素子のうち、受光素子は光吸収層の前面に多層反射膜が形成された構造の光検出器であることを特徴とする請求項１または２記載の光電気配線基板。

【請求項４】前記電気－光変換素子のうち、受光素子は光吸収層を挟むように両側に多層反射層が形成された構造の光検出器であることを特徴とする請求項１または２記載の光電気配線基板。

【請求項５】前記光導波路中に形成された前記集積型光路変換器は、光導波路伝播光を光導波路面に垂直な方向に曲げることで電気－光変換素子へ入射させ、かつ、電気－光変換素子からの出射光および多層反射膜からの反射光を光導波路面内方向に曲げることで光導波路へ導入させることを特徴とする請求項１乃至４の何れかに記載の光電気配線基板。

【請求項６】前記集積型光路変換器は、光導波路中に形成された突起状反射鏡からなることを特徴とする請求項１乃至５の何れかに記載の光電気配線基板。

【請求項７】前記集積型光路変換器は、光導波路中に形成された回折格子からなることを特徴とする請求項１乃至５の何れかに記載の光電気配線基板。

【請求項８】前記電気－光変換素子である発光素子には、搭載部品のバッファＣＭＯＳから、直接、駆動信号が印加される様に構成されていることを特徴とする請求項１乃至７の何れかに記載の光電気配線基板。

【請求項９】前記電気－光変換素子である多層反射膜による共振器構造を持つ受光素子は、該受光素子に生じた電圧変化を検出することで受信を行う様に構成されていることを特徴とする請求項１乃至８の何れかに記載の光電気配線基板。

【請求項１０】前記電気－光変換素子である発光素子および受光素子と隣接もしくは集積されて発光素子用駆動回路および受光素子用増幅回路がそれぞれ設けられていることを特徴とする請求項１乃至７の何れかに記載の光電気配線基板。

【請求項１１】光電気配線基板は、光導波路を含む層とは別に、グラウンド層および電源層を含んだ電気配線層が多層に形成されていることを特徴とする請求項１乃至１０の何れかに記載の光電気配線基板。

【請求項１２】前記光導波路は、クロック信号、管理制御信号、および複数のデータの伝送に充てられる様に構成されていることを特徴とする請求項１乃至１１の何れかに記載の光電気配線基板。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、クロックや管理制御などの信号伝送、プロセッサ、メモリ、グラフィックスなどのデータ伝送を行うために配線がなされたボードやマルチチップモジュールなどの配線基板に関するもので、特に伝送の一部を光で担う光電気配線基板に関するものである。

【０００２】

【従来技術】従来、ボードやマルチチップモジュールなどの実装基板上において、搭載部品を相互接続する配線としては電気配線が専ら使われている。しかしながら、搭載部品の中でも特にプロセッサ、クロック発振器、グラフィクスＬＳＩ、メモリなどからの或はこれらへの信号伝送は、高速広帯域な信号を扱うため、設計および実装上、様々な制限や問題が生じてきている。たとえば、以下のような制限や問題がある。

【０００３】・信号伝送の高速化制限

電気配線では、浮遊容量と抵抗の積で決まる時定数だけ信号伝播に遅延が生じる。従って、伝達情報の広帯域化、配線の微細化に伴い、全体の処理速度がトランジスタのスイッチング速度でなく、配線の遅延によって決まってしまうようになる。この信号遅延は大きな問題となっている。

【０００４】・配線の高密度化制限

線路間の相互インダクタンスを介した電磁誘導により、信号が相互に干渉し合う。線路間隔が狭いほど、また、信号の変化が高速になればなるほど、電磁干渉は顕著となる。

【０００５】・電磁放射の問題

クロック周波数の高周波化に伴い、線路からの電磁放射が生じやすくなる。デジタル信号であれば、その高調波も電磁放射の要因となる。そのため、ノイズや信号劣化、外部に対する電磁波障害も起きやすくなる。

【０００６】・消費電力の問題

配線の長距離化とクロック周波数の上昇により、配線容量（線路やボンディングパッドの浮遊容量）の充放電エネルギが大きくなり、これが消費電力を支配する状況になってきている。

【０００７】・配線容積／重量の問題

配線抵抗やインピーダンス整合のために線路幅を広くする必要がある。また、配線数の増加に伴い、実装、ケーブルの数量が増大、煩雑化している。

【０００８】電気配線においては、上記制限や問題に対して、配線材料を導電率の高い金属に置き換えたり、基板に誘電率の低い材料を選択したりしている。しかし、材料の違いによる性能改善の範囲は限られる。さらに、

上記低抵抗化、低誘電率化は、必ずしも電磁ノイズの解決とはならない。むしろ損失がある場合の方が電磁ノイズ発生を抑える効果もあり、仕様との兼合いを考えなければならず、問題解決は複雑である。

【０００９】電気配線もマイクロストリップラインのような伝送線路で構成すれば、１００ＭＨｚオーダーの高周波をベースに信号伝送が可能となる。こういった手法によれば、電磁界を或る程度閉じ込めて伝送できるため、電磁ノイズの問題も軽減される。しかしながら、配線のために、信号線路の下層および両脇などにグラウンド線や電源線を配する必要があり、その間隔や間隙の誘電率にも制限がある。そのため、設計上制限が大きく、また、或る程度の線路幅をとるので高集積化には不向きである。

【００１０】上記・乃至・に挙げた問題は、情報の高速、大容量化および処理の複雑化に伴い、今後さらに深刻さを増してくるため、電気信号で伝送を行う限り問題は完全には解決しない。

【００１１】

【発明が解決しようとする課題】光を伝送手段として用いれば、上記課題は本質的に大幅に改善される。それは、以下の理由による。

【００１２】・低損失・広帯域性

光線路は吸収、反射、散乱による伝播損失はあるものの、インピーダンスを考慮しなければならない電気線路とは伝送特性が異なる。また、伝送距離と伝送周波数はトレードオフであるが、光線路は、電気線路と比較して何れも優位にある。

【００１３】・耐電磁干渉性

光は電磁誘導を生じないし、電磁放射も生じない。従って、電磁環境の厳しい条件の下で使用されるのに適している。

【００１４】・グラウンド不要性

光子は電荷を持たず配線容量を充電する必要はない。よって、配線の抵抗と容量で決まる時定数による伝播遅延がなく、充放電にともなう電力消費のようなものもない。

【００１５】・小形・軽量

光線路を構成する誘電体あるいは高分子材料は、銅、金、アルミなどの金属に比べて軽い。ケーブルの例で説明すると、同じケーブルでも光ファイバは電気ケーブルとは比較にならないくらい小径かつ軽量になっている。

【００１６】・非干渉性

光線は交差しても信号の干渉を生じない。

【００１７】上記の利点を利用して、特開平９－９６７４６号公報では、基板上の光導波路に、電気から光への信号変換素子として光変調器を配置し、光から電気への信号変換素子として光検出器を配置して、光の信号伝送を行う構成が提案されている。しかしながら、レーザ光源からの出射光を光導波路に導入するため、光導波路端

面に光を結合する必要があり、レーザ光源と光導波路端面の位置合わせおよびその安定化が難しく、コスト高、大型化につながる。さらに、光検出器による受光によれば、信号光は終端してしまうため、バス配線などのように複数の部品間を接続する用途の実現は困難である。

【００１８】本発明は、上記従来技術の有する問題点に鑑み成されたものである。その目的は、光電気配線基板上に光信号の伝送を行う光導波路を備えて、（１）電気－光変換素子（本明細書においては、電気から光に変換する素子のみでなく光から電気に変換する素子も指す用語として用いている）を効率的かつ簡易に光導波路と結合させせられる、（２）複数の電気－光変換素子を同一光導波路上に配置できる、（３）任意の配線基板上に電気－光変換素子の形成が可能である、（４）作製が容易で且つ制御性が高い、（５）低コスト化が可能である、（６）高速広帯域の配線が可能である、（７）バス配線などのように複数の部品間を接続する用途にも使える、といった特徴を持つ光電気配線基板を提供することにある。

【００１９】

【課題を解決するための手段と作用】上記目的を達成するために、本発明の光電気配線基板は、光導波路が形成された光電気配線基板であって、多層反射膜を有した電気－光変換素子が該光導波路上に配置され、かつ、光の方向を折り曲げる光路変換器ないし結合器が該電気－光変換素子直下の光導波路中に集積化されて形成されていることを特徴とする。

【００２０】この基本構成に基づいて、以下の如き好適な形態が可能である。前記電気－光変換素子のうち、発光素子は活性層が多層反射膜で挟まれた構造の垂直共振器形面発光レーザ（ＶＣＳＥＬ）である。ＶＣＳＥＬは光導波路上に容易に制御性よく配置でき、アレイ化も容易で、駆動電流も小さくてよい。

【００２１】前記電気－光変換素子のうち、受光素子は、光吸収層の前面に多層反射膜が形成された構造の光検出器であったり、光吸収層を挟むように両側に多層反射層が形成された構造の光検出器であったりする。これにより、伝播光の一部を透過して検出し、残りは再び光路変換器を介して光導波路中を導波させる受光素子や、光吸収効率の良い受光素子が実現できる。

【００２２】前記光導波路中に形成された前記集積型光路変換器は、光導波路伝播光を光導波路面に垂直な方向に曲げることで電気－光変換素子へ入射させ、かつ、電気－光変換素子からの出射光および多層反射膜からの反射光を光導波路面内方向に曲げることで光導波路へ導入させる様な構造を有する。これにより、光導波路上に配置された電気－光変換素子を効率的かつ簡易に光導波路と結合させせられる。この集積型光路変換器は、光導波路中に形成された突起状反射鏡もしくは回折格子から好適に構成される。

【００２３】前記電気－光変換素子である発光素子には、搭載部品のバッファＣＭＯＳから、直接、駆動信号が印加される様に構成されたり、電気－光変換素子である多層反射膜による共振器構造を持つ受光素子は、該受光素子に生じた電圧変化を検出することで受信を行う様に構成され得る。この場合、発光素子用駆動回路、受光素子用増幅回路が不要となって、構成が簡単になる。

【００２４】勿論、前記電気－光変換素子である発光素子および受光素子と隣接もしくは集積されて発光素子用駆動回路および受光素子用増幅回路がそれぞれ設けられてもよい。

【００２５】光電気配線基板は、光導波路を含む層とは別に、グラウンド層および電源層を含んだ電気配線層が多層に形成され得る。また、前記光導波路は、クロック信号、管理制御信号、および複数のデータの伝送に充てられる様に構成され得る。

【００２６】

【発明の実施の形態】以下、図面を参照しつつ、本発明の実施例を説明していく。

【００２７】［第１実施例］図１は本発明による第１実施例の光電気配線基板を上から見た様子を示し、光電気配線基板上において、電気－光変換素子である面発光レーザ１１と光検出器１２が光導波路１３上に実装されている。光導波路１３に近接して、面発光レーザ１１の駆動回路１４および光検出器１２の増幅回路１５がチップとなって、光電気配線基板に集積されている。電気－光変換素子１１、１２と回路１４、１５は素子－回路間配線１６で繋がれている。

【００２８】面発光レーザ１１は、図２にも示すように、垂直共振器構造を有する。すなわち、高反射率（通常９９％以上）の多層反射膜２２、２４が活性層２３を挟むように成膜されている。よく知られている様に、この構造の面発光レーザ１１においては、活性層２３で発生する光のうち多層反射膜２２、２４で共振される波長の光が増幅され発振に至り、出射光２９を生じる。

【００２９】光導波路１３脇に形成した駆動回路チップ１４から面発光レーザ１１への駆動信号の伝送、および、増幅回路チップ１５への光検出器１２からの信号伝送を行う電気配線１６は、光電気配線基板上に設けるか、あるいは光電気配線基板内部に形成した多層電気配線を通して行われる。

【００３０】本実施例における面発光レーザ１１は以下の様に作製される。先ず、図２に示すように、ｎ－ＧａＡｓ基板２１上に、ｎ－ＡｌＡｓ／ＡｌＧａＡｓ３０組からなる多層反射膜２２、ＡｌＧａＡｓスペーサで挟みこまれたＧａＡｓ／ＡｌＧａＡｓ多重量子井戸からなる活性層２３、ｐ－ＡｌＡｓ／ＡｌＧａＡｓ２０組からなる多層反射膜２４が一回のエピタキシャル成長で形成される。本実施例では、発振波長が８３０ｎｍとなるように、活性層２３で決まるホトルミネセンス波長と、多層反射膜２２、２４の反射波長帯と、多層反射膜２２、２４間の間隔から決まるファブリペロエタロン波長とを制御している。また、ｐ側の多層反射膜２４の上層には、電極２７との導通を良好に図るためにｐ－ＧａＡｓ層が形成されている。

【００３１】次に、内径１０μｍ－φ、外径４０μｍ－φのドーナツ状に活性層２３下部まで反応性イオンエッチング法などで垂直にエッチングを行う。次いで、選択的ウエットエッチングで活性層２３をくびらせた後、ＳｉＮｘで絶縁膜２５を成膜した後、ポリイミドからなる埋め込み層２６を形成し、ｐ電極パターン２７を形成する。続いて、薄片化したｎ－ＧａＡｓ基板２１裏面にｎ電極２８を成膜した後、アロイングを行い、ｐ電極２７およびｎ電極２８とＧａＡｓ層とのオーミック接触を得る。

【００３２】光検出器１２も面発光レーザ１１と同様に作製する。ただし、活性層２３の代わりにＧａＡｓ層からなる光吸収層とし、多層反射膜は光吸収層上部にのみ形成する。面発光レーザのように電流狭窄のためのくびれ形成は必要なく、受光は電極の受光窓を通して行う。

【００３３】光導波路上には、図３に示すように、面発光レーザ３０１と光検出器３０２とが実装される位置に、導電層（たとえばＡｕ／Ｎｉ／Ｃｕ多層薄膜）３０３が成膜されている。更に、その上部に半田メッキ層（たとえばＡｕ／Ｓｎ共晶半田）３０４が成膜される。上記の如く作製した面発光レーザ３０１と光検出器３０２は、表面側を下にして、半田メッキ層３０４を介してｐ電極２７側が光導波路上の導電層３０３に実装される。導電層３０３および半田メッキ層３０４には、面発光レーザ３０１および光検出器３０２のための透光窓を開けている。

【００３４】光導波路は、多層電気配線基板３０５上にクラッド３０６、３０７と共に形成されたコア層３０８から成る。クラッド３０６、３０７とコア３０８とは、互いに屈折率の異なる（コア３０８の方が大きい）透明なポリイミドをスピナコーティングし、続いてキュアを行うことで成膜する。面発光レーザ３０１および光検出器３０２を実装する直下には、突起状反射鏡３０９、３１０が形成されている。突起状反射鏡３０９、３１０は、下層クラッド層３０６成膜後に、別個作製した三角柱を寝かせた形状の金属ティップ（たとえばＡｕ）を下層クラッド層３０６上に圧着接合して形成される。コア３０８および上層クラッド３０７はその後に成膜する。

【００３５】この突起状反射鏡３０９、３１０は、集積型光結合器ないし光路変換器として、面発光レーザ３０１の垂直下方出射光３１１を光導波路コア３０８へ伝播させる役目を担う。あるいは、光導波路コア３０８の伝播光３１２を垂直上方に反射させ光検出器３０２へ向かわせる。光検出器３０２へ入射した光は、光吸収層３１３の前面に形成された多層反射膜３１４において一部透

過され、光吸収層３１３にて検出される。残りは多層反射膜３１４にて反射される反射光３１５となり、突起状反射鏡３１０を介して再び光導波路中を伝播していく。面発光レーザ３０１直下の突起状反射鏡３０９に遭遇した伝播光は反射され、面発光レーザ３０１へ向かうが、活性層３１６を挟んだ上下の高反射率の多層反射膜３１７にて殆ど損失することなく反射され、光導波路コア３０８を再び伝播していく。

【００３６】以上の構成により、レーザ光源の出射光を光導波路の端面から入射させる手間がなく、レーザ光源を光電気配線基板上へフリップチップ実装（レーザ光源の電極と電気配線の電極パッドの両者が実装接合面の間に完全に隠れた状態で実装する実装）することで、その出射光を光導波路へ効率良く結合させることが可能となる。また、光導波路を伝播する光は光検出器に必要なパワーのみを与え、残りは通過する。そのため、たとえば、面発光レーザからの光信号を多段の光検出器で受けることができ、プロセッサ間、メモリ間のクロック信号分配などを自由に行うことができる。

【００３７】［第２実施例］図４および図５を参照して、本発明による第２の実施例を説明する。光電気配線基板は、図４に示すように、電源層およびグラウンド層を含めて６層の電気配線層からなる多層セラミック基板４０１上に光導波路層４０２が形成され、さらにその上部に電気－光変換素子と電子回路が集積された光電変換チップ４０３が形成されて成る。また、他の配線基板との接続用に、コネクタ４０４が実装されている。

【００３８】本実施例では、光導波路４０２と光電変換チップ４０３とを光学的に接続する集積型光結合器として、屈折率変調構造を利用する。すなわち、図５に示すように、面発光レーザ５０１および光検出器５０２直下の光導波路コア５０３中に、光伝播を面内方向から垂直方向あるいはその逆方向に折り曲げる屈折率変調構造５０４、５０５がそれぞれ形成されている。面発光レーザ５０１からの光信号は、図４の符号４０５に模式的に示すように、光導波路層４０２中を伝送し、一つもしくは複数の光検出器５０２で受信される。

【００３９】光導波路層４０２の作製は次の様に行なわれる。まず、多層セラミック基板４０１上に、バッファ層として、ＰＳＧ（燐シリカガラス）層５０６を成膜し、続いて、ＧＰＳＧ（ゲルマ燐シリカガラス）を２層塗布する。２層のうち、光導波路コアとなるＧＰＳＧ層５０３は、下層のＧＰＳＧ層５０７と比較してゲルマの含有量を高く設定することで、屈折率が高くなっている。次に、面発光レーザ５０１および光検出器５０２直下となる部位に、光導波路コア５０３の伸長方向と直交するように屈折率変調構造である回折格子５０４および５０５を形成する。回折格子５０４、５０５の作製方法は、まず、フォトレジストを光導波路コア５０３上に塗布後に、電子ビーム露光により回折格子パターンを潜像させ、現像を経てエッチングマスクを得る。そして、エッチングマスクを通して、イオンビームエッチングにより光導波路コアとなるＧＰＳＧ層５０３を回折格子状に掘り込む。続いて、複数の電気－光変換素子を適当に繋ぐような光導波路コア５０３の配線パターンを、同様にフォトリソグラフィにより作製する。そして、さらに下層クラッド５０７と同等の屈折率を有するＧＰＳＧからなる上層クラッド５０８を回折格子を埋め込みながら成膜して、回折格子５０４、５０５付きの光導波路コアパターンを形成する。屈折率変調構造５０４、５０５の周期Λは、光導波路の実効屈折率をn_eとして、伝播波長をλとすれば、$\Lambda = 2\lambda / n_e$となる。

【００４０】多層セラミック基板４０１には、光電変換チップ４０３のための電源、グラウンド、および信号伝送を担う電気配線層４０６が形成されている。電気配線層４０６間の接続に必要なヴィアホール（ｖｉａ ｈｏｌｅ）４０７も備えられ、これは、多層セラミック基板４０１や光導波路層４０２を通して孔を開け、そこに必要な金属メッキを施すことで形成される。

【００４１】面発光レーザ５０１および光検出器５０２は、Ｓｉウェハ５０９上に、導電層５１０、半田メッキ層５１１を介して実装される。Ｓｉウェハ５０９、導電層５１０、半田メッキ層５１１には、光入出射用に開口５２０が形成されていて、光導波路コア５０３との光結合ができるようになっている。ただし、発光素子の波長をＳｉの透過波長（たとえば、１．３μｍ、１．５５μｍ）で設計すれば、Ｓｉウェハ５０９には開口を形成する必要はなくなる。続いて、面発光レーザ５０１および光検出器５０２が実装されたＳｉウェハ５０９を光導波路層４０２上に接着剤５１２（たとえばエポキシ）を介して実装する。

【００４２】図６は、図４および図５中の光電変換チップ４０３を説明する図である。面発光レーザ６０２と光検出器６０３が実装されたＳｉウェハ６０１には、それぞれ駆動回路６０４と増幅回路６０５が形成されている。面発光レーザ６０２と光検出器６０３は、それぞれ駆動回路６０４と増幅回路６０５に隣接して実装されるため、チップ間配線は極端に短くなっている（不図示）。また、駆動回路６０４と増幅回路６０５はヴィアホール４０７を通して多層セラミック基板４０１に接続される。

【００４３】プロセッサ、メモリ、グラフィックＬＳＩなどの高周波部品４０８は、光電気配線基板４０１、４０２に実装する際、駆動回路６０４および増幅回路６０５の端子に実装される。図６では、駆動回路６０４への電気信号入力６０６および増幅回路６０５からの電気信号出力６０７がそれぞれ模式化して描かれている。面発光レーザ、光検出器などの電気－光変換素子を通して、高速な信号およびデータは光電気配線基板上を光にて伝送される。無論、直流回路あるいは低周波回路に相当す

る配線は、光導波路下層に存在する電気配線層４０６を介して伝送される。ただし、低周波であってもデジタル信号等においては、その高調波が電磁ノイズを発生しやすいため、光導波路を通して伝送することが好ましい。

【００４４】［第３実施例］以下、図７を用いて、本発明による第３の実施例を説明する。面発光レーザ７０１は、高反射率（通常９９％以上）の多層反射膜７０２で活性層７０３を挟むように構成した垂直共振器構造を持つ。光検出器７０４は、面発光レーザ７０１と同様に、多層反射膜７０５および７０６で光吸収層７０７が挟まれる構造を持っている。ただし、前面の多層反射膜７０５の反射率は、８０～９０％程度になるように多層膜の層数を制御している。

【００４５】面発光レーザ７０１と光検出器７０４は、同一ウェハ上に結晶成長されていて、光検出器７０４の前面多層膜反射鏡７０５のみ、反射率を下げる目的でエッチングされている（符号７３０の部分参照）。前面多層反射膜７０２、７０５上には、コンタクト層となるｐ－ＧａＡｓ層７０８も結晶成長されている。更にコンタクト電極７０９が蒸着されている。ただし、図７においては、ｎ－ＧａＡｓウェハ側（図の上側）は省略してある。

【００４６】光導波路上には、面発光レーザ７０１と光検出器７０４とが配置される位置に、導電層（たとえばＡｕ／Ｎｉ／Ｃｕ多層薄膜）７１０が成膜されている。更に、その上部に半田メッキ層（たとえばＡｕ／Ｓｎ共晶半田）７１１が成膜される。同一ウェハ上に作製した面発光レーザ７０１と光検出器７０４とは、表面側（同一ウェハの反対側）を下にして、半田メッキ層７１１を介してｐ電極７０９側が光導波路上の導電層７１０に実装される。導電層７１０および半田メッキ層７１１には、面発光レーザ７０１および光検出器７０４のための透光窓が開けられている。

【００４７】光導波路は、光電気配線基板７１２上にクラッド７１３、７１４と共に形成されたコア層７１５からなる。クラッド７１３、７１４とコア７１５とは互いに屈折率の異なる（コア７１５の方が大きい）透明なポリイミドをスピナコーティングし、続いてキュアを行うことで成膜する。面発光レーザ７０１および光検出器７０４を実装する直下には、周期的な突起からなる反射鏡７１６、７１７が形成されている。周期的反射鏡７１６、７１７の作製は次の様に行なわれる。まず、下層クラッド層７１３を成膜後に、金属薄膜（たとえばＡｕ）を成膜し、フォトレジストを塗布後、二光束干渉露光法により回折格子を形成する。続いて、この回折格子の形成されたフォトレジストマスクを通して金属薄膜をエッチングすることで周期的反射鏡７１６、７１７が得られる。コア７１５および上層クラッド７１４はその後に成膜する。

【００４８】この周期的反射鏡７１６、７１７は、集積型光結合器ないし光路変換器として、面発光レーザ７０１の垂直下方出射光７１８を光導波路コア７１５へ伝播させる役目を担う。あるいは、光導波路コア７１５の伝播光７１９を垂直上方に反射させ光検出器７０４へ向かわせる。周期的反射鏡７１６、７１７の突起周期は、第２実施例と同様である。

【００４９】光検出器７０４は多層反射膜７０５、７０６で挟まれた共振器構造となっているため、伝播波長に強い感度を有する。ただし、光吸収層７０７の前面に形成された多層反射膜７０５は反射率を高くしていない為、光検出器７０４の共振波長の帯域幅は比較的広く、面発光レーザ７０１の発振波長が多少変動しても、その感度に影響はない。以上の効果で、集積型光結合器７１７を経た伝播光７１９は、光吸収層７０７にて検出される。そして、多層反射膜７０５で反射された残りの光７２０は、周期的反射鏡７１７を介して再び光導波路中を伝播していく。面発光レーザ７０１直下の突起状反射鏡７１６に遭遇した伝播光は、ここで反射され面発光レーザ７０１へ向かうが、高反射率の多層反射膜７０２にて殆ど損失することなく反射され、再び光導波路コア７１５を伝播していく。こうして、バス配線型の信号光の送出・検出ができる。

【００５０】面発光レーザ７０１は動作電流のオーダがｍＡ程度と低いため、本実施例では、搭載部品のバッファＣＭＯＳからの電気信号およびデータを、直接、面発光レーザに印加することで、光伝送を行っている。更には、多層反射膜７０５、７０６による共振器構造に起因して光検出器７０４の検出感度ないし光吸収効率が向上するため、光検出器に生じた電圧変化を検出することで受信を行う。従って、発光素子用駆動回路および受光素子用増幅回路は不要となる。光電気配線基板における電気－光変換はこれらの面発光レーザと共振器付き光検出器で達成されるため、光電気配線基板の小型化および省電力化を進めることができる。

【００５１】

【発明の効果】以上説明したように、本発明による光電気配線基板を用いることにより、配線基板からの電磁放射ノイズ発生が抑圧され、配線路の線幅、距離にかかわらず、低電力での高速信号伝送が行える。そして、光導波路の幅は数μｍから数１０μｍであり得て、且つ、光導波路同士が互いに電磁的に非干渉であるため、配線基板上に高密度な配線が可能な実装を実現できる。

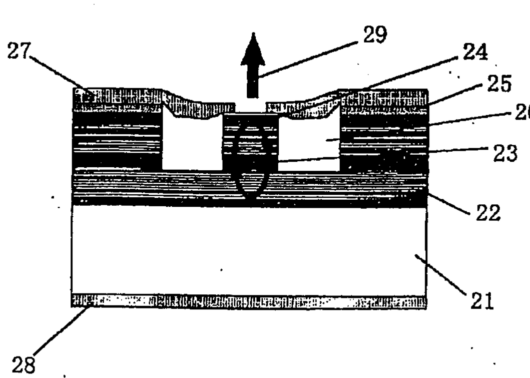
【００５２】また、本発明によれば、光導波路と電気－光変換素子とを容易に結合可能なため、量産性に優れた光電気配線基板を作製できる。さらに、本発明による光電気配線基板は、多層電気基板の併用も容易に行え、用途とニーズに応じて任意に対応できる。

【図面の簡単な説明】

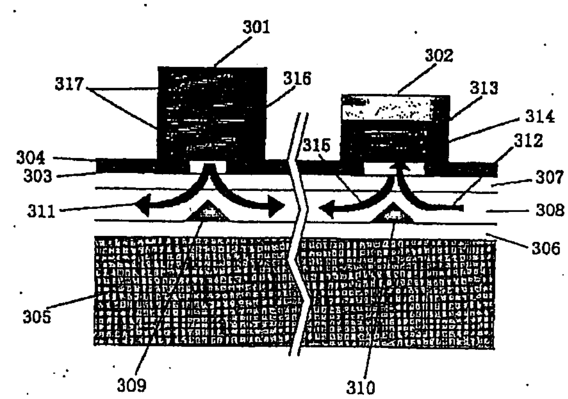
【図１】本発明による光電気配線基板を説明する平面図である。

【図２】本発明による光電気配線基板を構成する面発光レーザの構造を示す断面図である。
【図３】本発明による光電気配線基板における電気－光変換素子および光導波路の構成を示す断面図である。
【図４】本発明による光電気配線基板の他の実施例を説明する斜視図である。
【図５】本発明による他の実施例の光電気配線基板における電気－光変換素子および光導波路の構成を示す断面図である。
【図６】本発明による面発光レーザ、光検出器、駆動回路、増幅回路を実装した光電変換チップを説明する斜視図である。
【図７】本発明による更に他の実施例の光電気配線基板における電気－光変換素子および光導波路の構成を示す断面図である。
【符号の説明】
１１、３０１、５０１、６０２、７０１　面発光レーザ
１２、３０２、５０２、６０３、７０４　光検出器
１３、４０２　光導波路（光導波路層）
１４、６０４　駆動回路チップ
１５、６０５　増幅回路チップ
１６　素子－回路間配線
２１　レーザ基板
２２、２４、３１４、３１７、７０２、７０５、７０６　多層反射膜
２３、３１６、７０３　活性層
２５　絶縁膜
２６　埋込み層
＊２７、２８、７０９　電極
２９　出射光
３０３、５１０、７１０　導電層
３０４、５１１、７１１　半田メッキ層
３０５、４０１、７１２　多層基板（多層電気配線基板）
３０６、３０７、５０７、５０８、７１３、７１４　光導波路クラッド
３０８、５０３、７１５　光導波路コア
３０９、３１０、５０４、５０５、７１６、７１７　集積型光結合器（光路変換器）
３１１、７１８　レーザ出射光
３１２、７１９　光導波路伝播光
３１３、７０７　光吸収層
３１５、７２０　反射光
４０３　光電変換チップ
４０４　コネクタ
４０５　光信号
４０６　電気配線層
４０７　ヴィアホール
４０８　高周波部品
５０６　バッファ層
５０９、６０１　Ｓｉウェーハ
５１２　接着剤
５２０　透光窓（開口）
６０６　電気信号入力
６０７　電気信号出力
７０８　コンタクト層
＊　７３０　多層反射膜７０５のエッチング部

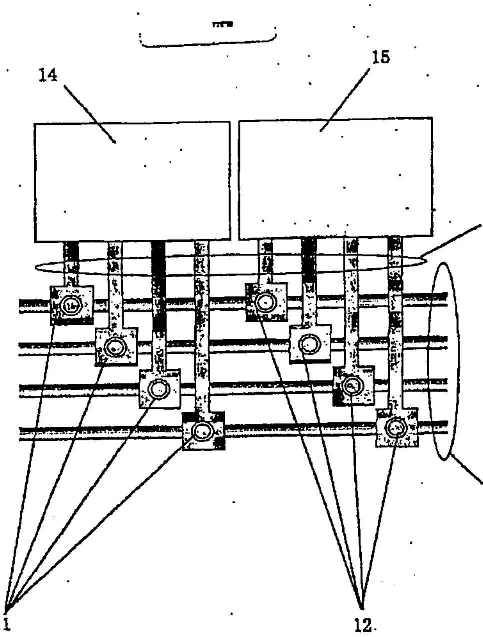
【図２】



【図３】



【図１】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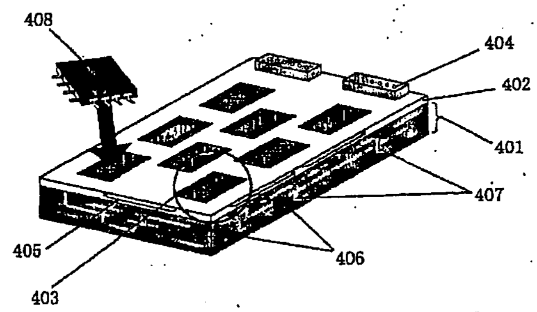
【図４】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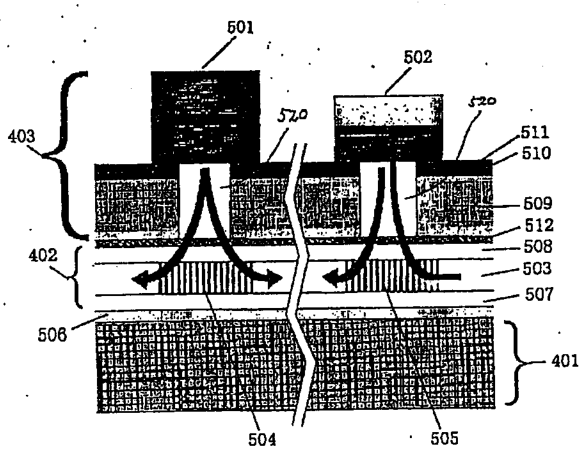
【図５】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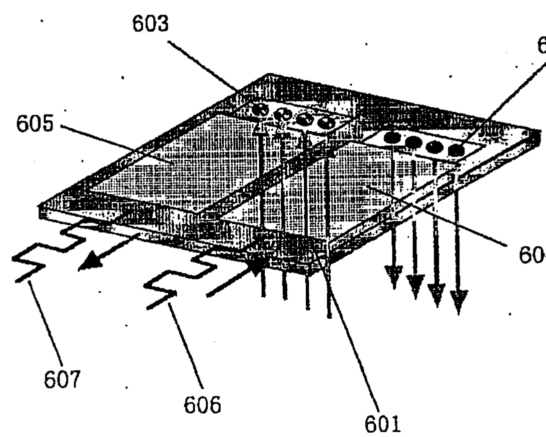
【図６】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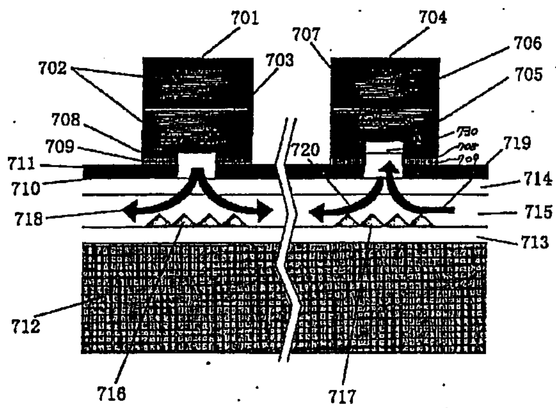
【図７】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PATENT ABSTRACTS OF JAPAN

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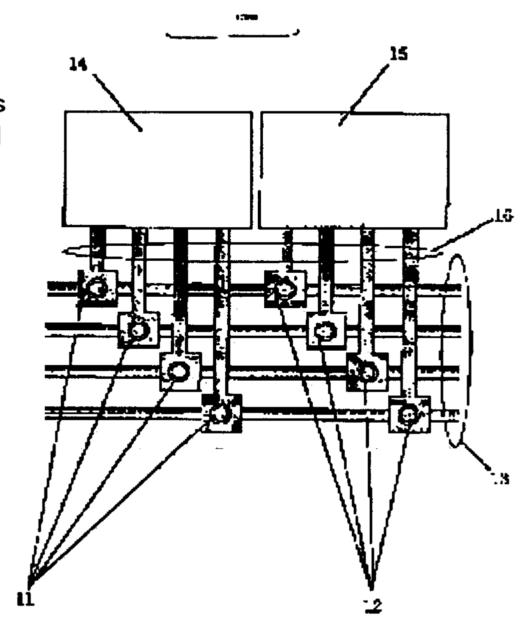
(54) OPTO-ELECTRIC WIRING BOARD

(57)Abstract:



PROBLEM TO BE SOLVED: To make it possible to easily couple optical waveguides and electric-optical conversion elements having multiplayered reflection films by arranging the elements on the optical waveguides and integrating optical path converters or couplers for bending the direction of light in the optical waveguides right under the electric-optical conversion elements, thereby forming an electro-optic wiring board formed with the optical waveguides in an electro-optic wiring board formed with the optical waveguides.

SOLUTION: Surface light emitting lasers 11 which are the electric-optical conversion elements and photodetectors 12 are packaged on the optical waveguides 13 on the electro-optic wiring board. A drive circuit 14 for the surface light emitting lasers 11 and an amplifier circuit 15 of the photodetectors 12 are integrated in proximity to the optical waveguides 13 in the form of chips to the electro-optic wiring board. The electric-optical conversion elements 11 and 12 and the circuits 14 and 15 are connected by wiring 16 between the elements and the circuits. As a result, there is no labor for making the exit light of laser beam sources on the optical waveguides from their end faces and the efficient coupling of the exit light to the optical wavegudies is made possible by the flip-chip packaging of the laser beam sources onto the electro-optic wiring board.

LEGAL STATUS

[Date of request for examination]

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[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

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CLAIMS

[Claim(s)]
[Claim 1] The photoelectricity wiring substrate which is a photoelectricity wiring substrate with which optical waveguide was formed, and is characterized by integrating and forming the optical-path converter which electric-light-transforming element with the multilayer reflective film is arranged on this optical waveguide, and bends the direction of light into the optical waveguide directly under this electric - light-transforming element.
[Claim 2] It is the photoelectricity wiring substrate according to claim 1 characterized by a light emitting device being the perpendicular resonator form face luminescence laser (VCSEL) of the structure where the barrier layer was inserted by the multilayer reflective film among said electric - light-transforming elements.
[Claim 3] It is the photoelectricity wiring substrate according to claim 1 or 2 characterized by a photo detector being the photodetector of the structure where the multilayer reflective film was formed in the front face of a light absorption layer among said electric-light-transforming elements.
[Claim 4] It is the photoelectricity wiring substrate according to claim 1 or 2 characterized by a photo detector being the photodetector of the structure where the multilayer reflecting layer was formed in both sides so that a light absorption layer might be pinched among said electric-light-transforming elements.
[Claim 5] Said accumulation mold optical-path converter formed into said optical waveguide is a photoelectricity wiring substrate given in claim 1 thru/or any of 4 they are ON to electric - light-transforming element by bending optical waveguide propagation light in the direction perpendicular to an optical waveguide side. [which is characterized by making it introduce to optical waveguide by making it shoot and bending the outgoing radiation light from electric-light-transforming element, and the reflected light from the multilayer reflective film to optical waveguide side inboard]
[Claim 6] Said accumulation mold optical-path converter is a photoelectricity wiring substrate given in claim 1 thru/or any of 5 they are. [which is characterized by consisting of a letter reflecting mirror of a projection formed into optical waveguide]
[Claim 7] Said accumulation mold optical-path converter is a photoelectricity wiring substrate given in claim 1 thru/or any of 5 they are. [which is characterized by consisting of a diffraction grating formed into optical waveguide]
[Claim 8] A photoelectricity wiring substrate given in claim 1 thru/or any of 7 they are. [which is characterized by the thing by which a driving signal is directly impressed to the light emitting device which is said electric-light-transforming element from the buffer CMOS of loading components, and which is constituted like]
[Claim 9] The photo detector with the resonator structure by the multilayer reflective film which is said electric - light-transforming element is a photoelectricity wiring substrate given in claim 1 thru/or any of 8 they are. [which is characterized by being constituted so that it may receive by detecting electrical-potential-difference change produced in this photo detector]
[Claim 10] A photoelectricity wiring substrate given in claim 1 thru/or any of 7 they are. [which is characterized by being adjoined or accumulated with the light emitting device and photo

detector which are said electric-light-transforming element, and preparing the drive circuit for light emitting devices, and the amplifying circuit for photo detectors, respectively]
[Claim 11] A photoelectricity wiring substrate is a photoelectricity wiring substrate given in claim 1 thru/or any of 10 they are. [which is characterized by forming the electric wiring layer containing a ground plane and a voltage plane in a multilayer apart from the layer containing optical waveguide]
[Claim 12] Said optical waveguide is a photoelectricity wiring substrate given in any [a clock signal, a supervisory control signal and claim 1 characterized by the thing by which transmission of two or more data is allotted, and which is constituted like thru/or] of 11 they are.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the photoelectricity wiring substrate which bears a part of transmission with light especially about wiring substrates with which wiring was made, such as a board and a multi chip module, in order to perform data transmission, such as signal transmissions, such as a clock and supervisory control, a processor, memory, and graphics.

[0002]
[Description of the Prior Art] Conventionally, as wiring which interconnects loading components on mounting substrates, such as a board and a multi chip module, electric wiring is used chiefly. However, in order to treat a signal [broadband at high speed / especially the signal transmission to these / from a processor, a clock generator, Graphics LSI, memory, etc.] also in loading components, various limits and problems are arising on a design and mounting. For example, there are the following limits and problems.
[0003] - In the high speed limit electric wiring of a signal transmission, delay produces only the time constant decided by the product of stray capacity and resistance in signal propagation. Therefore, the whole processing speed comes to be decided not by the switching rate of a transistor but by delay of wiring with broadband-izing of transfer information, and detailed-izing of wiring. This signal delay poses a big problem.
[0004] - By the electromagnetic induction through the mutual inductance between the densification limit tracks of wiring, a signal interferes each other mutually. So that track spacing is narrow, and the more change of a signal becomes a high speed, the more electromagnetic compatibility becomes remarkable.
[0005] - It becomes easy to produce the electromagnetic radiation from a track with RF-izing of the problem clock frequency of electromagnetic radiation. If it is a digital signal, the higher harmonic will also cause electromagnetic radiation. Therefore, the electromagnetic wave disorder to a noise, or signal degradation and the exterior also becomes easy to occur.
[0006] - By long-distance-izing of problem wiring of power consumption, and the rise of a clock frequency, the electrical charge and discharge energy of wiring capacity (stray capacity of a track or a bonding pad) becomes large, and it is becoming the situation that this governs power consumption.
[0007] - It is necessary to make track width of face large for problem wiring resistance of the wiring volume / weight, or impedance matching. Moreover, it followed on the increment in the number of wiring, and it has increased and the quantity of mounting and a cable has made it complicated.
[0008] In electric wiring, to the above-mentioned limit or a problem, a wiring material is transposed to a metal with high conductivity, or the ingredient with a low dielectric constant is chosen as a substrate. However, the range of the engine-performance improvement by the difference in an ingredient is restricted. furthermore, the above-mentioned reduction in resistance and the reduction in a dielectric constant -- not necessarily -- electromagnetism -- it does not become solution of a noise. the direction in case **** is with a loss rather --

electromagnetism -- it is effective in suppressing noise generating, balance with a specification must be considered, and the problem solving is complicated.
[0009] If constituted from the transmission line [like a microstrip line] whose electric wiring is also, a signal transmission will become possible based on the high frequency of 100MHz order. according to such technique -- electromagnetic field -- since [a certain] it grade-shuts up and can transmit -- electromagnetism -- the problem of a noise is also mitigated. However, it is necessary to allot a ground line and a power-source line to a lower layer, both the sides, etc. of a signal-line way, and the spacing and dielectric constant of a gap also have a limit for wiring. Therefore, a limit on a design is large, and since the track width of face which is a certain extent is taken, it is unsuitable for high integration.
[0010] Since the problem mentioned to above-mentioned - thru/or - will increase seriousness further with an informational high speed, large-capacity-izing, and complication of processing from now on, as long as it transmits with an electrical signal, a problem is not solved completely.
[0011]
[Problem(s) to be Solved by the Invention] If light is used as a transmission means, the above-mentioned technical problem will essentially improve sharply. It is based on the following reasons.

[0012] - A transmission characteristic differs from the electric track where propagation loss according [low loss and a broadband nature beam-of-light way] to absorption, reflection, and dispersion must take the impedance of a certain thing into consideration. Moreover, although a transmission distance and transmission frequency are trade-ofves, a beam-of-light way has all in dominance as compared with an electric track.
[0013] - -proof -- electromagnetism -- coherence light does not produce electromagnetic induction and does not produce electromagnetic radiation, either. Therefore, it is suitable for being used under the severe conditions of an electromagnetic environment.
[0014] - A ground unnecessary nature photon does not need to charge wiring capacity without a charge. Therefore, there is no propagation delay by the time constant decided by resistance and capacity of wiring, and there is also nothing like the power consumption accompanying charge and discharge.
[0015] - The dielectric or polymeric materials which constitutes small / lightweight beam-of-light way is light compared with metals, such as copper, gold, and aluminum. If the example of a cable explains, an optical fiber is a minor diameter and a light weight also by the same cable to the extent that it does not become as compared with an electrical cable.
[0016] - Even if an incoherent light line crosses, it does not produce interference of a signal.
[0017] By JP,9-96746,A, the configuration which arranges an optical modulator to the optical waveguide on a substrate as a signal transformation component from the electrical and electric equipment to light, arranges a photodetector to it as a signal transformation component from light to the electrical and electric equipment, and performs the signal transmission of light to it is proposed using the above-mentioned advantage. However, in order to introduce the outgoing radiation light from a laser light source into optical waveguide, it is necessary to combine light with an optical waveguide end face, and the alignment of a laser light source and an optical waveguide end face and its stabilization are difficult, and lead to cost quantity and enlargement. Furthermore, according to light-receiving by the photodetector, in order to carry out termination of the signal light, implementation of the application which connects between two or more components like bus wiring is difficult.
[0018] This invention is accomplished in view of the trouble which the above-mentioned conventional technique has. The purpose is equipped with the optical waveguide which transmits a lightwave signal on a photoelectricity wiring substrate, and is a (1) electrical-and-electric-equipment-light-transforming element (in this specification). it uses as vocabulary which points out not only the component changed into light from the electrical and electric equipment but the component changed into the electrical and electric equipment from light -- **** -- it is combined with optical waveguide efficiently and simply -- (2) Two or more electric-light-transforming elements on the wiring substrate of (3) arbitration which can be arranged on the same optical waveguide [which can form electric-light-transforming element] (4) It is in offering

a photoelectricity wiring substrate with the description that production can be used also for the application which connects between two or more components like (7) bus wiring in which wiring of (6) high-speed broadband in which the easy formation of (5) low cost with a high controllability is possible is possible.
[0019]
[Means for Solving the Problem and its Function] In order to attain the above-mentioned purpose, the photoelectricity wiring substrate of this invention is characterized by integrating and forming the optical-path converter thru/or coupler which is the photoelectricity wiring substrate with which optical waveguide was formed, and electric-light-transforming element with the multilayer reflective film is arranged on this optical waveguide, and bends the direction of light into the optical waveguide directly under this electric - light-transforming element.
[0020] Based on this basic configuration, the suitable gestalt like a less or equal is possible. A light emitting device is the perpendicular resonator form face luminescence laser (VCSEL) of the structure where the barrier layer was inserted by the multilayer reflective film, among said electric-light-transforming elements. It can arrange VCSEL(ing) with a sufficient controllability easily on optical waveguide, array-izing may also be easy to VCSEL for it, and its drive current may also be small.
[0021] Among said electric - light-transforming elements, a photo detector is the photodetector of the structure where the multilayer reflective film was formed in the front face of a light absorption layer, or is the photodetector of the structure where the multilayer reflecting layer was formed in both sides so that a light absorption layer might be pinched. Thereby, a part of propagation light is penetrated and detected, and the remainder can realize the photo detector to which the guided wave of the inside of optical waveguide is again carried out through an optical-path converter, and a photo detector with sufficient light absorption effectiveness.
[0022] It has structure which is made to introduce to optical waveguide by carrying out incidence of said accumulation mold optical-path converter formed into said optical waveguide to electric - light-transforming element by bending optical waveguide propagation light in the direction perpendicular to an optical waveguide side, and bending the outgoing radiation light from electric - light-transforming element, and the reflected light from the multilayer reflective film to optical waveguide side inboard. Thereby, electric - light-transforming element arranged on optical waveguide is combined with optical waveguide efficiently and simply. This accumulation mold optical-path converter consists of suitably a letter reflecting mirror of a projection formed into optical waveguide, or a diffraction grating.
[0023] Directly, the photo detector with the resonator structure by the multilayer [which it is constituted like or is electric-light-transforming element] reflective film to which a driving signal is impressed may be constituted from a buffer CMOS of loading components by the light emitting device which is said electric - light-transforming element so that it may receive by detecting electrical-potential-difference change produced in this photo detector. In this case, the drive circuit for light emitting devices and the amplifying circuit for photo detectors become unnecessary, and a configuration becomes easy.
[0024] Of course, it may be adjoined or accumulated with the light emitting device and photo detector which are said electric-light-transforming element, and the drive circuit for light emitting devices and the amplifying circuit for photo detectors may be prepared, respectively.
[0025] Apart from the layer in which a photoelectricity wiring substrate contains optical waveguide, the electric wiring layer containing a ground plane and a voltage plane may be formed in a multilayer. Moreover, said optical waveguide may be constituted by a clock signal, a supervisory control signal, and the appearance allotted to transmission of two or more data.
[0026]
[Embodiment of the Invention] Hereafter, the example of this invention is explained, referring to a drawing.
[0027] [1st example] drawing 1 shows signs that the photoelectricity wiring substrate of the 1st example by this invention was seen from the top, and the surface emission-type laser 11 and photodetector 12 which are electric - light-transforming element are mounted on optical waveguide 13 on the photoelectricity wiring substrate. Optical waveguide 13 is approached, the

drive circuit 14 of a surface emission-type laser 11 and the amplifying circuit 15 of a photodetector 12 serve as a chip, and the photoelectricity wiring substrate is accumulated. The electric-light-transforming elements 11 and 12 and circuits 14 and 15 are tied by the wiring 16 between component-circuits.
[0028] A surface emission-type laser 11 has perpendicular resonator structure, as shown also in drawing 2 . That is, membranes are formed so that the multilayer reflective film 22 and 24 of a high reflection factor (usually 99% or more) may sandwich a barrier layer 23. In the surface emission-type laser 11 of this structure, the light of the wavelength which resonates by the multilayer reflective film 22 and 24 among the light generated in a barrier layer 23 is amplified, it results in an oscillation, and the outgoing radiation light 29 is produced as known well.
[0029] Electric wiring 16 which performs the signal transmission from the photodetector 12 to transmission of a driving signal and the amplifying-circuit chip 15 to a surface emission-type laser 11 from the drive circuit chip 14 formed in the optical waveguide 13 side is performed through the multilayer electric wiring which prepared on the photoelectricity wiring substrate or was formed in the interior of a photoelectricity wiring substrate.
[0030] The surface emission-type laser 11 in this example is produced as follows. First, as shown in drawing 2 , the barrier layer 23 which consists of a GaAs/AlGaAs multiplex quantum well which inserted and was crowded with the multilayer reflective film 22 and AlGaAs spacer which consist of 30 sets of n-AlAs/AlGaAs, and the multilayer reflective film 24 which consists of 20 sets of p-AlAs/AlGaAs are formed with 1 time of epitaxial growth on the n-GaAs substrate 21. The photo-luminescence wavelength decided by the barrier layer 23, the reflected wave length band of the multilayer reflective film 22 and 24, and the multilayer reflective film 22 and the Fabry-Perot etalon wavelength decided from spacing between 24 are controlled by this example so that oscillation wavelength is set to 830nm. Moreover, in order to aim at a flow with an electrode 27 good, the p-GaAs layer is formed in the upper layer of the multilayer reflective film 24 by the side of p.
[0031] Next, it etches perpendicularly by a reactive-ion-etching method etc. up to the barrier layer 23 lower part in the shape of [of bore 10 micrometer-phi and outer-diameter 40 micrometer-phi] a doughnut. Subsequently, after forming the barrier layer 23 by alternative wet etching and forming an insulator layer 25 by SiNx after **********, the embedding layer 26 which consists of BORIIMIDO is formed, and p electrode pattern 27 is formed. Then, after forming the n electrode 28 at the n-GaAs substrate 21 flake-ized rear face, alloying is performed and ohmic contact in the p electrode 27 and the n electrode 28, and a GaAs layer is acquired.
[0032] The photodetector 12 as well as a surface emission-type laser 11 is produced. However, it considers as the light absorption layer which consists of a GaAs layer instead of a barrier layer 23, and the multilayer reflective film is formed only in the light absorption layer upper part. Like a surface emission-type laser, the vena-contracta formation for a current constriction is unnecessary, and light-receiving is performed through the light-receiving aperture of an electrode.
[0033] The conductive layer (for example, Au/nickel/Cu multilayered film) 303 is formed by the location where a surface emission-type laser 301 and a photodetector 302 are mounted on optical waveguide as shown in drawing 3 . Furthermore, the solder deposit (for example, Au/Sn eutectic solder) 304 is formed by the upper part. Like the above, the surface emission-type laser 301 and photodetector 302 which were produced turn a front-face side down, and the p electrode 27 side is mounted in the conductive layer 303 on optical waveguide through the solder deposit 304. The translucent window for a surface emission-type laser 301 and a photodetector 302 is opened in the conductive layer 303 and the solder deposit 304.
[0034] Optical waveguide consists of the core layer 308 formed with clads 306 and 307 on the multilayer electric wiring substrate 305. Clads 306 and 307 and a core 308 form membranes by carrying out spinner coating of the transparent polyimide with which refractive indexes differ mutually (the core 308 is larger), and performing a cure continuously. The letter reflecting mirrors 309 and 310 of a projection are formed in directly under [which mounts a surface emission-type laser 301 and a photodetector 302]. After lower layer cladding layer 306 membrane formation, the letter reflecting mirrors 309 and 310 of a projection carry out sticking-

by-pressure junction of the metal tip (for example, Au) of a configuration which laid down the triangle pole which carried out separate production on the lower layer cladding layer 306, and are formed. A core 308 and the upper clad 307 form membranes after that.

[0035] These letter reflecting mirrors 309 and 310 of a projection bear the duty which makes the perpendicular lower part outgoing radiation light 311 of a surface emission-type laser 301 spread to the optical waveguide core 308 as an accumulation mold optical coupling machine thru/or an optical-path converter. Or the propagation light 312 of the optical waveguide core 308 is reflected in the perpendicular upper part, and it is made to face to a photodetector 302. The light which carried out incidence to the photodetector 302 is penetrated in part in the multilayer reflective film 314 formed in the front face of the light absorption layer 313, and is detected in the light absorption layer 313. The remainder serves as the reflected light 315 reflected by the multilayer reflective film 314, and spreads the inside of optical waveguide again through the letter reflecting mirror 310 of a projection. Although it is reflected and the propagation light which encountered the letter reflecting mirror 309 of a projection of surface emission-type laser 301 directly under goes to a surface emission-type laser 301, it is reflected without losing almost by the multilayer reflective film 317 of a high reflection factor of the upper and lower sides which sandwiched the barrier layer 316, and it spreads the optical waveguide core 308 again.

[0036] There is no time and effort to which incidence of the outgoing radiation light of a laser light source is carried out from the end face of optical waveguide, and the above configuration enables it to combine the outgoing radiation light efficiently to optical waveguide by carrying out photoelectricity wiring substrate top HEFURIPPU chip mounting (mounting mounted after the electrode of a laser light source and both of the electrode pad of electric wiring have hidden completely between mounting planes of composition) of the laser light source. Moreover, the light which spreads optical waveguide gives only power required for a photodetector, and the remainder passes. Therefore, for example, a multistage photodetector can receive the lightwave signal from a surface emission-type laser, and the clock signal distribution between interprocessor and memory etc. can be performed freely.

[0037] The 2nd example by this invention is explained with reference to [2nd example] drawing 4 and drawing 5 . The optical waveguide layer 402 is formed on the multilayered ceramic substrate 401 which consists of a six-layer electric wiring layer including a voltage plane and a ground plane, the photo-electric-conversion chip 403 with which electric-light-transforming element and the electronic circuitry were further accumulated on the upper part is formed, and a photoelectricity wiring substrate changes, as shown in drawing 4 . Moreover, the connector 404 is mounted in connection with other wiring substrates.

[0038] In this example, refractive-index modulated structure is used as an accumulation mold optical coupling machine which connects optically optical waveguide 402 and the photo-electric-conversion chip 403. That is, as shown in drawing 5 , the refractive-index modulated structures 504 and 505 which bend optical propagation from field inboard to a perpendicular direction or its hard flow are formed, respectively into the surface emission-type laser 501 and the optical waveguide core 503 of photodetector 502 directly under. As typically shown in the sign 405 of drawing 4 , the lightwave signal from a surface emission-type laser 501 transmits the inside of the optical waveguide layer 402, and is received by one or two or more photodetectors 502.

[0039] Production of the optical waveguide layer 402 is performed as follows. First, on a multilayered ceramic substrate 401, as a buffer layer, the PSG (phosphorus silica glass) layer 506 is formed, then two-layer spreading of the GPSG (germanium phosphorus silica glass) is carried out. The GPSG layer 503 which serves as an optical waveguide core among two-layer is setting up the content of germanium highly as compared with the lower layer GPSG layer 507, and the refractive index is high. Next, the diffraction gratings 504 and 505 which are refractive-index modulated structures as it intersects perpendicularly with the expanding direction of the optical waveguide core 503 are formed in the part which becomes a surface emission-type laser 501 and directly under photodetector 502. First, after applying a photoresist on the optical waveguide core 503, the production approach of diffraction gratings 504 and 505 carries out the latent image of the diffraction-grating pattern by electron beam exposure, and obtains an etching mask through development. And it lets an etching mask pass and the GPSG layer 503 which

serves as an optical waveguide core by ion beam etching is dug deep in the shape of a diffraction grating. Then, the circuit pattern of the optical waveguide core 503 which connects suitably two or more electric-light-transforming elements is similarly produced by the photolithography. And the upper clad 508 which consists of GPSG which has a refractive index still more equivalent to the lower layer clad 507 is formed embedding a diffraction grating, and a diffraction grating 504 and an optical waveguide core pattern with 505 are formed. The period lambda of the refractive-index modulated structures 504 and 505 sets the effective refractive index of optical waveguide to n0, and serves as lambda, then lambda=2 lambda/n 0 in propagation wavelength.

[0040] The power source for the photo-electric-conversion chip 403, the ground, and the electric wiring layer 406 that bears a signal transmission are formed in the multilayered ceramic substrate 401. It also has the veer hole (via hole) 407 required for connection between the electric wiring layers 406, this opens a hole through a multilayered ceramic substrate 401 or the optical waveguide layer 402, and it is formed by performing metal plating required there.

[0041] A surface emission-type laser 501 and a photodetector 502 are mounted through a conductive layer 510 and the solder deposit 511 on the Si wafer 509. Opening 520 is formed in optical ON outgoing radiation, and optical coupling with the optical waveguide core 503 has come be made at the Si wafer 509, a conductive layer 510, and the solder deposit 511. If the wavelength of a light emitting device is designed by the transmitted wave length (for example, 1.3 micrometers, 1.55 micrometers) of Si, it will become unnecessary however, to form opening in the Si wafer 509. Then, the Si wafer 509 with which the surface emission-type laser 501 and the photodetector 502 were mounted is mounted through adhesives 512 (for example, epoxy) on the optical waveguide layer 402.

[0042] Drawing 6 is drawing explaining the photo-electric-conversion chip 403 in drawing 4 and drawing 5 . The drive circuit 604 and the amplifying circuit 605 are formed in the Si wafer 601 in which the surface emission-type laser 602 and the photodetector 603 were mounted, respectively. Since a surface emission-type laser 602 and a photodetector 603 are adjoined and mounted in the drive circuit 604 and an amplifying circuit 605, respectively, wiring between chips is extremely short (un-illustrating). Moreover, the drive circuit 604 and an amplifying circuit 605 are connected to a multilayered ceramic substrate 401 through the veer hole 407.

[0043] In case the RF components 408, such as a processor, memory, and Graphic LSI, are mounted in the photoelectricity wiring substrates 401 and 402, they are mounted in the terminal of the drive circuit 604 and an amplifying circuit 605. In drawing 6 , respectively, and they are drawn. [the electrical signal input 606 to the drive circuit 604, and the electrical signal output 607 from an amplifying circuit 605] [**] [type] It lets electric - light-transforming elements, such as a surface emission-type laser and a photodetector, pass, and a high-speed signal and data are transmitted with light in a photoelectricity wiring substrate top. Of course, wiring equivalent to a direct current circuit or a low frequency circuit is transmitted through the electric wiring layer 406 which exists in an optical waveguide lower layer. however -- even if it is low frequency -- a digital signal etc. -- setting -- the higher harmonic -- electromagnetism -- since it is easy to generate a noise, transmitting through optical waveguide is desirable.

[0044] The 3rd example by this invention is explained using drawing 7 below the [3rd example]. A surface emission-type laser 701 has the perpendicular resonator structure constituted so that a barrier layer 703 might be inserted by the multilayer reflective film 702 of a high reflection factor (usually 99% or more). The photodetector 704 has the structure where the light absorption layer 707 is pinched by the multilayer reflective film 705 and 706, like the surface emission-type laser 701. However, the reflection factor of the front multilayer reflective film 705 is controlling the number of layers of multilayers to become about 80 - 90%.

[0045] Crystal growth of a surface emission-type laser 701 and the photodetector 704 is carried out on the same wafer, and they are etched in order only for the front multilayers reflecting mirror 705 of a photodetector 704 to lower a reflection factor (refer to the part of a sign 730). On the front multilayer reflective film 702 and 705, crystal growth also of the p-GaAs layer 708 used as a contact layer is carried out. Furthermore, the contact electrode 709 is vapor-deposited. However, in drawing 7 , the n-GaAs wafer side (on drawing) is omitted.

[0046] The conductive layer (for example, Au/nickel/Cu multilayered film) 710 is formed by the location where a surface emission-type laser 701 and a photodetector 704 are arranged on optical waveguide. Furthermore, the solder deposit (for example, Au/Sn eutectic solder) 711 is formed by the upper part. The surface emission-type laser 701 and photodetector 704 which were produced on the same wafer turn a front-face side (opposite side of the same wafer) down, and the p electrode 709 side is mounted in the conductive layer 710 on optical waveguide through the solder deposit 711. The translucent window for a surface emission-type laser 701 and a photodetector 704 has opened in the conductive layer 710 and the solder deposit 711.
[0047] Optical waveguide consists of a core layer 715 formed with clads 713 and 714 on the photoelectricity wiring substrate 712. Clads 713 and 714 and a core 715 form membranes by carrying out spinner coating of the transparent polyimide with which refractive indexes differ mutually (the core 715 is larger), and performing a cure continuously. The reflecting mirrors 716 and 717 which consist of a periodic projection are formed in directly under [which mounts a surface emission-type laser 701 and a photodetector 704]. Production of the periodic reflecting mirrors 716 and 717 is performed as follows. First, after forming the lower layer cladding layer 713, a metal thin film (for example, Au) is formed, and a diffraction grating is formed by the two-beam-interference exposing method after applying a photoresist. Then, the periodic reflecting mirrors 716 and 717 are obtained by etching a metal thin film through the photoresist mask with which this diffraction grating was formed. A core 715 and the upper clad 714 form membranes after that.
[0048] These periodic reflecting mirrors 716 and 717 bear the duty which makes the perpendicular lower part outgoing radiation light 718 of a surface emission-type laser 701 spread to the optical waveguide core 715 as an accumulation mold optical coupling machine thru/or an optical-path converter. Or the propagation light 719 of the optical waveguide core 715 is reflected in the perpendicular upper part, and it is made to face to a photodetector 704. The projection period of the periodic reflecting mirrors 716 and 717 is the same as that of the 2nd example.
[0049] Since the photodetector 704 has resonator structure inserted by the multilayer reflective film 705 and 706, it has sensibility strong against propagation wavelength. However, the multilayer reflective film 705 formed in the front face of the light absorption layer 707 does not have effect in the sensibility, even if the bandwidth of the resonant wavelength of a photodetector 704 is comparatively wide and it changes somewhat the oscillation wavelength of a surface emission-type laser 701, since the reflection factor is not made high. The propagation light 719 which passed through the accumulation mold optical coupling machine 717 by the above effectiveness is detected in the light absorption layer 707. And the remaining light 720 reflected by the multilayer reflective film 705 spreads the inside of optical waveguide again through the periodic reflecting mirror 717. Although it is reflected here and the propagation light which encountered the letter reflecting mirror 716 of a projection of surface emission-type laser 701 directly under goes to a surface emission-type laser 701, it is reflected without losing almost by the multilayer reflective film 702 of a high reflection factor, and it spreads the optical waveguide core 715 again. In this way, sending out and detection of the signal light of a bus wiring mold can be performed.
[0050] Since a surface emission-type laser 701 has the order of the operating current as low as mA extent, in this example, it is impressing the electrical signal and data from Buffer CMOS of loading components to a surface emission-type laser directly, and is performing optical transmission. Furthermore, since it originates in the resonator structure by the multilayer reflective film 705 and 706 and the detection sensitivity thru/or light absorption effectiveness of a photodetector 704 improves, it receives by detecting electrical-potential-difference change produced in the photodetector. Therefore, the drive circuit for light emitting devices and the amplifying circuit for photo detectors become unnecessary. Since electric - light conversion in a photoelectricity wiring substrate is attained by these surface emission-type lasers and the photodetector with a resonator, it can advance a miniaturization and power-saving of a photoelectricity wiring substrate.
[0051]

[Effect of the Invention] As explained above, by using the photoelectricity wiring substrate by this invention, electromagnetic radiation noise generating from a wiring substrate is oppressed, and high speed signal transmission with low power can be performed irrespective of the line breadth of a wiring way, and distance. And since the width of face of optical waveguide may be several micrometers to several 10 micrometers and optical waveguides are noninterfering electromagnetic mutually, mounting in which high-density wiring is possible is realizable on a wiring substrate.
[0052] Moreover, according to this invention, the photoelectricity wiring substrate which was easily excellent in mass-production nature in optical waveguide and electric - light-transforming element since it was combinable is producible. Furthermore, the photoelectricity wiring substrate by this invention can also perform easily concomitant use of a multilayer electrical-and-electric-equipment substrate, and can respond to arbitration according to an application and needs.

[Translation done.]

* NOTICES *

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is a top view explaining the photoelectricity wiring substrate by this invention.
[Drawing 2] It is the sectional view showing the structure of the surface emission-type laser which constitutes the photoelectricity wiring substrate by this invention.
[Drawing 3] It is the sectional view showing the configuration of electric-light-transforming element in the photoelectricity wiring substrate by this invention, and optical waveguide.
[Drawing 4] It is a perspective view explaining other examples of the photoelectricity wiring substrate by this invention.
[Drawing 5] It is the sectional view showing the configuration of electric-light-transforming element in the photoelectricity wiring substrate of other examples by this invention, and optical waveguide.
[Drawing 6] It is a perspective view explaining the photo-electric-conversion chip which mounted the surface emission-type laser by this invention, the photodetector, the drive circuit, and the amplifying circuit.
[Drawing 7] It is the sectional view showing the configuration of electric-light-transforming element in the photoelectricity wiring substrate of the example of further others by this invention, and optical waveguide.
[Description of Notations]
11,301,501,602,701 Surface emission-type laser
12,302,502,603,704 Photodetector
13,402 Optical waveguide (optical waveguide layer)
14,604 Drive circuit chip
15,605 Amplifying-circuit chip
16 Wiring between Component-Circuits
21 Laser Substrate
22, 24, 314, 317, 702, 705, 706 Multilayer reflective film
23,316,703 Barrier layer
25 Insulator Layer
26 Pad Layer
27 28,709 Electrode
29 Hikaru Idei
303, 510, 710 Conductive layer
304, 511, 711 Solder deposit
305, 401, 712 Multilayer substrate (multilayer electric wiring substrate)
306, 307, 507, 508, 713, 714 Optical waveguide clad
308, 503, 715 Optical waveguide core
309, 310, 504, 505, 716, 717 Accumulation mold optical coupling machine (optical-path converter)

311 718 Laser Hikaru Idei
312 719 Optical waveguide propagation light
313 707 Light absorption layer

315 720 Reflected light
403 Photo-Electric-Conversion Chip
404 Connector
405 Lightwave Signal
406 Electric Wiring Layer
407 Veer Hole
408 RF Components
506 Buffer Layer
509 601 Si wafer
512 Adhesives
520 Translucent Window (Opening)
606 Electrical Signal Input
607 Electrical Signal Output
708 Contact Layer
730 Etching Section of Multilayer Reflective Film 705

[Translation done.]